Towards an Integrated Approach to Watershed Planning: The role of land cover, human preference, and biotic condition in managing Puget Sound lowland streams.

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Keywords: riparian, preference, planning

1. Introduction

In the Seattle metropolitan region, decades of urban growth have culminated in the federal listing of the Puget Sound Chinook and several other species of salmon. The listing requires urban and regional planners to address the degradation of salmon habitat in Puget Sound streams by including scientific and social considerations in the framing of policies and regulations. Two central issues are relevant for managing urban streams under the mandates of the Endangered Species Act (ESA). First, is the assessment and inclusion of key scientific findings that relate factors of development to degradation of habitat. Second, planning agencies must involve the local citizens to develop and, ultimately, support plans to safeguard impaired waters. To accomplish this, urban planners must garner support from elected officials to ensure that adequate budgets and legislation is available for addressing plan implementation. At its core, the urban planning process involves multiple agencies working with the best available information to implement plans that satisfy local citizens and public officials.

Management strategies for protecting salmon habitat have encountered formidable obstacles when applied to watersheds in the Puget Sound metropolitan region. There exist limitations in the availability of appropriate scientific information, in particular scientific information that applies to urban areas. In a review of the scientific studies used by urban planners conducted by the author in collaboration with others, we found that analyses of watersheds and local riparian zones are based in areas where few, if any, human inhabitants reside (Francis et. al., 2005; Mills et al. 2005). While research on non-urban streams has emphasized the importance of 'best management practices' (BMPs) such as vegetated buffers, urban areas contain physical impediments (i.e. buildings, walkways, etc.) and human activities (i.e. gardening, pruning, re-vegetation, etc.) that preclude the application of BMPs along all portions of the steam channel. Moreover, physical features such as roads, power-lines, and landscaping practices break the connectivity of vegetation commonly associated to riparian corridors with limited human interference. As a result, in areas where riparian buffering is not possible information about the influence of up-land vegetation connectivity becomes essential to watershed managers charged with protecting degradation of aquatic resources.

Another limitation regarding the availability of appropriate science for addressing issues relevant to aquatic habitats concerns the lack of studies addressing the interactions of mechanisms that operate at multiple scales. Investigations into what modifications at the landscape scale interact with local effects of land use to impact the riparian zone need further development (Wang et al, 1997; Roy et al. 2005). To date, the majority of catchment-scale studies has only indirectly indicated tradeoffs, as in the common finding that biological metrics are negatively associated with developed land in the catchment but positively associated with forested land in the riparian area (Steedman, 1988; Wang et al., 2001). Estimates of total developed land or total impervious surface do not address evidence that the location, distribution, and configuration of watershed features influences stream condition (Alberti, et al. 2004). The same can be said for the relationship between the composition and distribution of riparian vegetation and maintaining sufficient habitat for aquatic organisms.

While the importance of social preference in determining the condition of corridor vegetation has been discussed in the literature (Lant and Roberts, 1990; Nassauer, et. al., 2001) there also exists a disconnect between the scientific basis for habitat protection, preference for riparian vegetation by streamside residents, and application of policies that utilize information from both. A review of the literature suggests that policies aimed at protecting streams fail to incorporate both the scientific basis of watershed integrity (Pedersen et al., 1992; Osbourne and Kovacic, 1993; Allan and Flecker, 1993; Dunaway et. al., 1994), and the social values of watershed residents (Zube et al., 1975;; Kaplan and Kaplan, 1982; Brown and Harris, 1998; Nassauer et. al., 2001). Especially in 'human dominated ecosystems' such as the PSL, managing areas with diverse private property holdings (e.g. over 73% of streamside channels in the PSL are zoned Single-Family-Resident and privately owned), and a multiplicity of resident activities along the stream channel (e.g. fertilizing, landscaping, recreation) requires an understanding of the constellation of factors that influence landowner willingness to conserve and create riparian forests, and society's general preference for the best policies for reforesting riparian lands. Given these gaps in the best available information, a central question emerges and defines the over-arching question for this study: how can urban ecological information *in* *conjunction with* preferences of watershed residents be used to aid urban planners in developing watershed management strategies?

2. Research Design

I seek to develop an integrated framework that links the biophysical conditions of riparian and watershed vegetation conditions with planning strategies that engage streamside residents' preferences for vegetation. By focusing on the role of vegetation patterns in maintaining the biotic integrity of stream conditions, I ask two questions: (1) how do landscape-scale vegetation patterns influence the effectiveness of local riparian buffering strategies? and (2) how can information about the social preferences of watershed residents in conjunction with ecological information aid urban planners in developing appropriate riparian management strategies? To address the first question, I use nonparametric regression analysis to test two specific hypotheses: (1) there is no significant relationship between the amount of local vegetation and in-stream biological condition that is not already explained by watershed vegetation conditions; and (2) there is no significant relationship between *connectivity* of vegetation and in-stream biological condition that is not already explained by the total amount of watershed vegetation. I address the second question, with a survey based on the subjective states format (Flower and Hayes, 1980). The survey measures streamside resident perceptions, feelings and judgments of varying configurations of riparian vegetation.

I present this study in three parts. The first and second sections address the specific research questions by providing a background on what gaps exist in the literature, methods for operationalizing variables, analysis and results. The final section integrates results from both sections to address the over-arching question.

3. Watershed Vegetation Patterns and In-stream Biotic Conditions

I systematically select several basins for testing these hypotheses. I use a selection scheme that is organized hierarchically -- from the watershed-scale, controlling influential factors from the landscape (Turner, 1989), to the local-scale—with vegetation conditions from least-impacted to severely disturbed. Table 3-1 provides a summary of the landscape feature, mechanism, and operationalized variable for characterizing both spatial scales.

Table 3-1: Selection Criteria for Basins and Local Sampling Sites

LANDSCAPE FEATURE / MANAGEMENT CRITERIA	MECHANISM	PROXIMATE VARIABLE / DESCRIPTION
Basin Scale		
Basin Size	Hydrological regime, quantity, quality and velocity of discharge	Size of basin (KM^2)
Development	Fragmentation of vegetation	Impervious suface and forested area
Anadromous Fish	ESA Listing	Urgency -- Number of listed species
Local Scale		
Riparian Vegetation	Regulation of energy inputs, temperature, filtering, channel stability	Diversity of riparian vegetation conditions
Limited land use regulation	Changes in riparian vegetation	Single family residence
Multiple Channel Locations	In-stream monitoring	Accessibility for field crew

Given the above mechanisms operating at the watershed and local scales, Table 3-2 (next page) describes eight basins in the PSL contain the necessary landscape variables, large tracks of residential areas, and several points for local access.

Table 3-2: Study Basins

Basin	Landuse	Landcover	
	Residential Amount	Percent Impervious Surface in Basin	Percent Forest in Basin
Thornton	72.52%	85.75%	12.10%
Pipers	39.00%	57.00%	18.00%
Swamp	42.69%	43.82%	23.26%
North	46.42%	40.98%	25.55%
Little Bear	60.50%	28.83%	40.76%
Rock (cedar)	0.00%	5.20%	90.00%
Big Bear	27.10%	21.10%	49.00%
Rock	10.32%	13.47%	74.79%

At one extreme is Thornton Creek with large percentage of residential areas, high amount of impervious surface, and limited forest in the drainage area. The other extreme is Rock Creek (Cedar), which is a tributary to Cedar River and serves as the reference site in this analysis. All other streams, with the exception of the Rock Creek (other), contain moderate amounts of residential areas (39 – 60%), impervious surface (28 – 57%), and forested area (18 – 49%) in the basin, making this suite of basins ideal for testing the hypotheses.

a. Methods

Vegetation conditions, namely composition and configuration, are quantified using FRAGSTATS software (McGarigal and Marks, 2000). I use percent land cover to characterize the composition of the drainage area. Configuration is described by a landscape metrics commonly cited as accurate descriptor – aggregation index (AI, Turner, 1991; Jager, 2000). The AI corresponds to the number of observed like adjacencies of vegetation divided by the maximum possible number of like adjacencies for the same class of vegetation. The AI ranges from 0 to 100, with basins containing larger, more aggregated patches having more adjacencies (higher metric value) than basins characterized by smaller, fragmented, disaggregated patches. The composition metric will aid in addressing the first hypothesis, and the configuration metrics provides insight into addressing the second hypothesis.

To characterize local riparian zone, I delineate the total contributing area for each point using a 10M digital elevation model (DEM). Each sampling point has a corresponding area that reflects the total upland draining area to that point. I characterize the land cover 100 meters adjacent to the stream channel (Washington State Department of Ecology's recommended 'buffering' distance). Each basin in the local riparian zone is characterized by selecting an area of 500 meters upstream from the sampling site. This distance provides a description of localized riparian conditions, contains sufficient sampling pixels for analysis, and isolates the riparian area for each sampling site from full channel features.

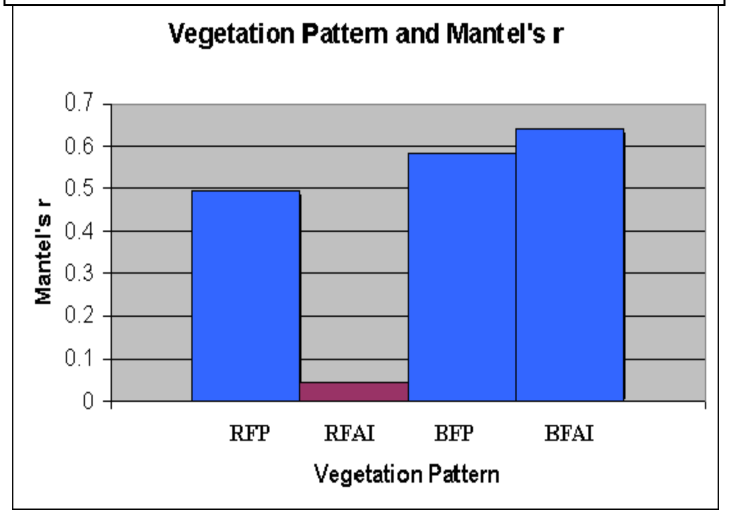
To test for in-stream impacts from vegetation patterns, I use the Benthic Index of Biotic Integrity (B-IBI). This measure is used by government agencies to characterize the biological integrity of streams systems. Using previously determined scoring thresholds for streams in the Puget Sound Lowlands (Karr and Chu, 2000), scores of one, three or five are assigned to each metric based on the raw metric value. A score of five suggests a value at or near what is expected at sites with little or no human influence, three is a value with some human influence or one a value occurring in stream systems with a great deal of human influence. Metric scores are averaged for three replicates to determine the site score for each metric, except for the "long-lived taxa" and "intolerant taxa" metrics, for which cumulative number of taxa across all three replicates are calculated. Scores for the 10 metrics are summed to determine BIBI for each study site. These scores are summed to obtain a site-and time-specific B-IBI score ranging from 10 (very poor) to 50 (excellent). Macroinvertebrates were collected and B-IBI developed during Fall of 2003 and 2004 for 44 sites)multiple sites along the stream channel) representing the range of landscape conditions.

To test the hypotheses I use a nonparametric regression analysis based on dissimilarity matrices. Specifically, I use a combination of Statistical Package for Social Science (SPSS Inc., Chicago IL), and R (Development Core Team, 2004) for applying the Mantel's test (Mantel, 1967) and the partial Mantel's test (Smouse et al. 1986). The primary reason for using a Mantel's regression analysis is because most ecological data exhibit some degree of spatial autocorrelation, depending on the scale at which the data were recorded and then analyzed (Legendre 1993; Fortin, 1999). Spatial autocorrelation is the phenomena where the patterns in which observations from near-by locations are more likely to have similar magnitude. The presence of spatial autocorrelation in the variables can affect the statistical significance and the interpretation of their degree of correlation (Legendre, 1993). Here, B-IBI and vegetation variables are likely to be spatially autocorrelated because macroinvertebrates have can have multiple source populations from which dispersion occurs, and vegetation dispersal mechanisms cause vegetation to grow where vegetation currently exists.

b. Results

I approach the detection of riparian and watershed influences on B-IBI through three steps. First, I estimated the degree of spatial autocorrelation in each of the landscape metrics using the simple Mantel's test. The simple Mantel's test computes the correlation between two distance matrices. In this case, one matrix is the linear (Euclidean) distance between sampling sites as a predictor variable, and the other is the vegetation conditions. Results indicate that the vegetation patterns are spatially autocorrelated among watershed (Mantel *r = 0.17 – 0.50, P < 0.001*). The spatial distribution of watershed scale vegetation patterns was particularly autocorrelated, as compared to riparian AI or total amount of riparian forest. These results suggest that procedures testing relationships between vegetation patterns and B-IBI scores will need to consider the influence of distance of sampling sites.

Figure 3-2: Results from simple Mantel tests of the riparian and basin vegetation conditions as a predictor of B-IBI.



Second, I examined the influence of different land cover patterns with B-IBI, also using simple Mantel's tests. One matrix is the B-IBI score, and the other represents the vegetation landscape variable. The result of this analysis is presented in Figure 3-2. Of all four predictors, only three were significant. Percentage riparian forest (RFP), percentage basin forest (BFP), and basin forest AI (BFAI) are significant predictors of B-IBI (Simple Mantel's test, r = 0.4924 (RFP), 0.582 (BFP), 0.6399 (BAI), all P <0.001). Riparian forest AI (RFAI) of local forest is the only metric that is not a significant (Mantel's r = 0.0446, P = 0.217) predictor of B-IBI.

The presence of spatial autocorrelation and multicollinearity between the sampling sites and the landscape variables, requires that I conduct a third step to isolate the influence of vegetation patterns on B-IBI – controlling for multiple influences. I examine three characteristics of the relationship between vegetation patterns and B-IBI by: (1) controlling for distance (of sampling sites) (2) controlling for watershed influence (BFP and BFAI); and (3) controlling for total basin forest (BFP). Results suggest that controlling for distance does not impact significance for each of the vegetation metrics, and only has a minor impact on the explanatory power (Mantel's r reduced by 0.13 –0.16). One exception to this is the RFAI which resulted in Mantel's r = - 0.024, P = 0.596. Negative numbers in Mantel's tests are rare, and suggest that RFAI is a noisy, heteroscedastic variable (Dutilleul, et al. 2000).
When controlling for watershed influences (BFP & BFAI), there is only a minor change in Mantel's r for RFP (reduction of 0.038, from 0.4929 to 0.4541). Finally, when controlling for BFP, and testing the amount of influence that the BFAI has on the B-IBI, Mantel's r values decrease 0.31(from 0.6399 to 0.3248). This is the most significant decrease, suggesting that both BPF and BFAI may be functioning together to influence B-IBI. I present a summary of all the partial Mantel's tests in Table 3-3 (next page).

To ensure that other potentially influential variables do not confound the results presented here, I conducted two additional analyses. Specifically, I examined the influence of one commonly cited land cover variable, impervious surface. The first analysis controlled for total amount of basin impervious surface and configuration of impervious surface, and examined the relative influence of BFP on B-IBI. Results suggest that total amount of impervious surface reduces the overall predictive power of the BFP more than any of the other variables, but BFP continues to be significant (Mantels' r = 0.2943 (total impervious surface) 0.3043 (aggregation of impervious surface), both P <0.001). In the second analysis, I examine the influence of BFAI on B-IBI , when controlling for total amount and aggregation of the basin impervious surface. These results are similar to the first analysis suggesting that BFAI is still a significant and strong predictor of B-IBI when controlling for basin impervious surface (Mantel's r = 0.4052

Table 3-3: Results from partial Mantel tests: riparian & basin vegetation as a predictor of B-IBI.

Landscape Variable	No Controls	Control				
		Distance	RFP	RFAI	BFP	BFAI
RFP						
Mantel's r	0.4924	0.4284		0.509	0.4541	0.4547
Significance	**	**		**	**	**
RFAI						
Mantel's r	0.04456	-0.0204	-0.1549		-0.0069	0.02388
Significance	0.217	0.596	0.998		0.508	0.268
BFP						
Mantel's r	0.5831	0.4951	0.5553	0.582		0.0119
Significance	**	**	**	**		0.447
BFAI						
Mantel's r	0.6399	0.5709	0.6178	0.6393	0.3248	
Significance	**	**	**	**	0.001	

***** P <0.001***

(total amount impervious surface), 0.4664 (aggregation of impervious surface), both P <0.001). When comparing Mantel's partial coefficients when controlling for impervious surface, BFAI has larger predicative power than BFP on B-IBI (Mantel's r = = 0.2943, 0.3043 (BFP), and 0.4052, 0.4664 (BFAI).

c. Discussion

The results address both aforementioned hypotheses. The first hypotheses suggested that there is no significant relationship between the amount of local vegetation and in-stream biological condition that is not already explained by watershed vegetation conditions. By holding the watershed vegetation constant, and testing for the influence of amount of vegetation, the results suggest rejection of the first null hypotheses. In fact, the Mantel's r remains significant, and is reduced by only 0.038, from 0.4929 to 0.4541, when watershed vegetation is held constant. These results suggest that the amount of local vegetation influences aquatic condition (as measured by B-IBI).

The second hypothesis suggests that there is no significant relationship between connectivity of vegetation and in-stream biological condition that is not already explained by the amount of watershed vegetation. In other words, if only the total amount of vegetation in the watershed mattered, regardless of configuration, then holding the watershed vegetation metric constant and testing the influence of vegetation configuration, should result in an insignificant value for BFAI. This is not the case -- Mantel's r is reduced, but BFAI still remains significant with a value of 0.3248 (P < 0.001). Accordingly, the second null hypothesis can also be rejected.

I submit that these results corroborate current understanding of ecological phenomena operating at the watershed and riparian scales, and that these results can be explained by different mechanisms operating at the different scales. At the landscape level, large patches of contiguous vegetation (high aggregation index) may reduce or slow down stormwater flows, and as a result, minimize overall 'flashiness' within the stream channel. Runoff frequency, volumes, and peak flow rates increase with fragmented forest conditions, and stream channels respond by increasing their cross-sectional area to accommodate the higher flows – either through widening of the stream channel, down-cutting of the streambed, or both (Lenat and Crawford, 1994; Boyer, et al. 2002). Aquatic insect diversity and abundance decrease because of changes in benthic substrates, dissolved oxygen level, sediment loading from bank erosion, and pollutant loadings occurring at the basin scale.

At the local scale, riparian vegetation provides shade, channel stability, sediment filtering, and nutrient inputs. Overland flow enters the riparian area as either sheet flow from upland areas or through small ephemeral drainage ways, allowing sediment to be deposited and other substances to be transformed. However, with the loss of upland tracks of vegetation, there is a formation of concentrated flows that is less likely to be dispersed within the riparian area, greatly reducing the potential for pollutant removal (Dillaha et al., 1989). A similar flow regime holds true for shallow subsurface flow and the removal dissolved substances. Accordingly, in these watersheds the importance of amount of riparian vegetation could be less with attenuating upland stormwater flows, and more with provision of necessary habitat conditions for in-stream organisms.

4. Human Preferences for Riparian Vegetation

Results from the previous section suggest that the amount of riparian vegetation is critical for stream health. One of the challenges in increasing the amount of riparian vegetation in urban watersheds is the fact that over 73%

of PSL streams are privately owned. Urban development through the creation of infrastructure fragments riparian corridors (Paul and Meyer, 2001; Alberti et al., 2004), while landowner preference for riparian vegetation may lead to isolated changes in the amount of vegetation adjacent to streams. Accordingly, examining the role of human preferences can provides insight into developing strategies for protecting riparian vegetation. In this section, I provide an analysis of human preference for riparian vegetation in PSL streams. I begin by describing a survey instrument used to illicit preferences of streamside residents, analyze results, and conclude with a discussion of findings.

a. Survey Instrument

The survey is based on the subjective states format (Flower and Hayes, 1980) and aims to measure streamside resident perceptions, feelings and judgments of varying configurations of riparian vegetation. By using publicly available county tax assessors' data, high resolution satellite data, and a GIS, I identify all parcels alongside the 8 sampling streams. Study subjects, residents living in single-family residents, receive questionnaires directed to the primary caretaker of the property. Each survey contains two sections, namely, visual preference ratings, and a section for preferred engagement methods -- a total of 27 questions. In the visual preference rating each survey participant is given a set of photographs depicting various configurations of riparian vegetation. By presenting 28 photos of differing riparian canopy configurations, participants are asked to imagine themselves in each scene, and then rate how much they like each scene from 1 to 10 (1 = dislike, 10 = preferred). Each part of the survey reinforces and mutually informs the next. For example, after rating their liking of the fist 14 photos, the next 14 photos in addition to rating asks what specifically do they like and dislike about each scene. Implicit in each photograph are the physical attributes (i.e. amount, density, type, and configuration), as well as the cognitive attributes associated to riparian vegetation. The features encompassed in each photograph will include: wild-land/mysterious (dense, multi-layered canopy, little or no human alteration), moderately maintained/limited human influence (some light penetration, upper and mid canopy intact), maintained (considerable light penetration, limited canopy, some infrastructure), managed/constant maintenance required (limited vegetation, ornamental species, heavy infrastructure), controlled (no vegetation, heavy infrastructure). This second section asks participants to answer questions related to the types of information they trust when considering a change to their property, the best method for communicating landscape stewardship information to them, and general experiences of living streamside.

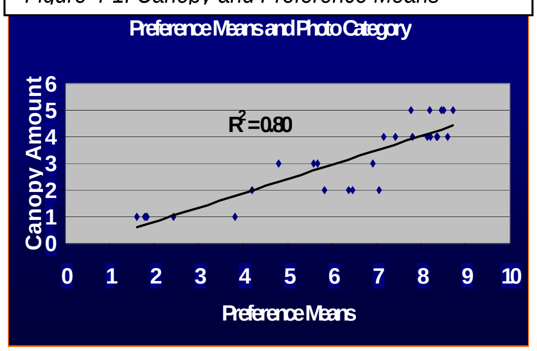
b. Human Preference Results

Of the 667 households that received the preference survey, a total of 272 streamside residents responded – over 41% response rate. The respondents consisted of 61% women and 39% men, with the average age of respondent between 50 and 59 years. Respondents have been living in Washington State for an average of 43 years, and in the current location for an average of 19.8 years.

Several tests were conducted to assess survey bias in respondents, including a comparison of respondents and non-respondents in regards to resident time at parcel, assessed value of homes, and location of responses. These tests of sampling bias suggest that the survey respondents were similar in regard to these characteristics.

The analysis of applying visual cues to solicit information regarding streamside riparian vegetation preference revealed three trends. First, several respondents stated that the scenes with large amounts of riparian vegetation "looked natural" or "looked beautiful" or contained a series of amenities (e.g. habitat, protection from erosion, potential for salmon). Second, and conversely, those scenes with limited riparian canopy, which were either channelized/armored or had considerable human modification, contained comments such as, "looks polluted", or "unnatural", or "looks dangerous". The biggest variance in aesthetic preferences for riparian vegetation involved photos with moderate human influence. In this section, there were favorable responses (e.g. "looks like a picnic area", "well kept") to unfavorable (e.g. "not enough trees", "lawns mean nitrogen loading into the stream"). When comparing across all 28 scenes there is a strong correlation between the amount of canopy and preference (R^2 = .80, P < 0.01), Figure 4-1.

Figure 4-1: Canopy and Preference Means



In the second portion of the survey, respondents were asked question to solicit the types of information they used when managing their property. This portion fell into three categories: most trusted, best method for communicating information, and general experiences of living along the stream. I address each of these systematically, by first focusing on the issue of most trusted source of information. When asked what sources of information are *most trusted* when making a decision about managing the property, 23% cited friends, family and neighbors. Similarly, 17% cited professional associations (e.g. Adopt-a-Stream Foundation, Washington Trout, etc.), and university scientists (20%). University extension services and watershed councils were cited 14% and 13% respectively. At the other end of the scale, only 5% of respondents cited county government as most trusted, with even fewer trusting federal (2%) and state (1%) agencies.

When referring to the best method for communicating information regarding care for the streamside property, an overwhelming number of people cited ‘newsletter’ (39%). The second most cited method was friends, family and neighbors (19%), followed by demonstration tour (9%), workshop (8%), and professional presentation (6%). Other respondents cited community projects (5%), watershed associations and display at local fair (4%), and presentation at a fair (2%). The remaining 5% (the ‘other’ category) cited websites, television programs, and newspapers as useful methods of communicating information about property management.

In the third and final analysis of the survey responses, specific attention is given to the overall experience of living along a stream. The data used to conduct this analysis was derived by comments provided by respondents. A total of 128 responses comprise this analysis, with all streams and locations represented the sample population. Table 4-1 identifies and describes each of the ten themes that emerged from the analysis.

Responses from survey participants could comprise multiple themes; however, the most commonly cited responses concerned ‘attitudes towards government’, ‘rules and regulations’, and ‘vegetation’. Comments concerning the theme of ‘attitude towards government’ contain responses such as:

TABLE 4-1: Survey Resonses by Theme

Response Themes	Description
Role of government	A description or expectation of the operations of government agencies
Rules and regulations	Specific laws as they apply to streams
Role of NGOs	Local non-governmental organizations that have been involved in stream activities
Ecological knowledge	A description of a specific ecological phenonomena
Attitude towards government	A value judgement as it relates to governing bodies
Information source	The need for information
Local environmental history	A description of a specific historical event as it relates to the stream
Salmon	Mention of salmon
Vegetation	Mention of plants, trees, grass in or around the stream
Stewardship	Activities as they relate to the preservation of the stream

“A few years ago we were cleaning things out of the creek (i.e. tires, garbage, etc.) and rearranging fallen trees so the salmon could come up; a government person ‘happened’ by and said we would be fined if we were ‘caught’…..Consequently, I haven’t appreciated or trusted government agencies”
or

“The only way Snohomish County would work with me is if I signed a conservation easement, but couldn't tell me any impact on my property value -- a very scary proposition to undertake with no info.”

Regarding rules and regulations, some comments include:

“What I fear most are the increased restrictions just because my property is on a stream”

or

“I am not in favor of some of the government rules and regs on my property that I pay the taxes on and purchased prior to those regulations and rules were put into effect.”

Other comments concerning vegetation include:

“I have many trees but not on the stream bank because it would block my view of the stream...”

or

"Snohomish County does not have a tree-retention ordinance. Consequently, our creek (Little Bear) is losing trees faster than can be imagined...."

The responses from streamside residents in combination with information of aesthetic preferences suggest that these residents in the PSL have considerable interest in seeing vegetation along the stream bank, as well as clean, healthy salmon-bearing waters. The question then becomes how to engage streamside residents in addressing these issues.

c. Discussion

The visual preference survey administered in this study provides the considerable insight into the complex interactions between vegetation preferences, attitude, and expected behavior of PSL streamside residents. By examining the comments of what respondents "liked" and "disliked" about each scene, and aligning these comments with preference ratings, there is sufficient evidence that participants were responding to the amount of canopy in each scene, and not other aspects of the picture. A few comments however, stated that the muddier waters, non-meandering channel, and evident erosion caused lower rating. These are characteristics of riparian areas with limited vegetation, and therefore, the comments were only providing further evidence for correlations between riparian canopy and stream condition. In addition, while there were no explicit questions regarding the connection between the scenes depicted in the photographs, and the individual respondents property, studies in visual preference provide substantial evidence regarding the positive correlation between the appearance of landscapes, and potential for developing conservation programs at the local scale (Kaplan and Kaplan, 1982; Golledge and Stimson, 1987; Nassauer, 2001). Accordingly, the assumption that respondents are linking preference for scenes with potential management options in their own property is substantiated in the literature.

i. Visual Preference

The results of the visual preference survey indicate two trends: first, survey respondents have a strong affinity for heavily forested landscapes and an aversion from scenes containing no vegetation (R2 = 0.80, P <0.001); and second, a wide range of preferences for photograph containing 'manicured' or landscaped areas ($3.95 \geq x \leq 7.30$). The strong affinity for heavily vegetated scenes may be caused for a variety of reasons; including archetypes of native riparian landscapes of the Northwest, fear of industrialized landscapes, or a combination of factors. In examining comments from respondents, however, scenes with both extremes (e.g. heavily canopied and channelized), suggest that an essential part of the stream was the vegetation along its banks. In other words, clean, cascading waters requires vegetation. These results corroborate previous studies that have identified streams as consistently associated with human perceptions of landscape beauty; and that streams that look muddy, or contain trash or are excessively modified through channels or culverts are ugly (Gregory and Davis, 1993; House and Fordham, 1991; Ryan, 2000).

For scenes with moderately less vegetation (category 4) there is not a substantial difference in response means (8.5 versus 8.0). In scenes containing a wide range of preferences, the data suggest that respondents have multiple reactions to the same landscape feature. For example, several scenes depict a grassy area adjacent to the stream channel. While some respondents cite the potential for a picnic area alongside the stream, others remark that lawns do not provide channel stability or increase fertilizer inputs. These responses indicate that a wide range of management options may be necessary for addressing the wide range of aesthetic, socio-economic, and educational characteristics of streamside residents.

ii. Engagement

Respondents to the survey stated that they trusted friends, family and neighbors, first and foremost, when considering changes to their property. While expected, there are other groups that were also strongly trusted as sources of information, such as professional associations, and university scientists. With the presence of Adopt-a-Stream foundation, and the University of Washington in the PSL, it may be obvious that residents are aligned with these groups. However, a striking pattern in the responses is the level of trust attributed to government agencies. Whether federal, state, county or local majority of respondents stated that they did not trust government agencies.

The other components to this study included, the preferred forms for communicating information regarding stream property management, and the general experience living streamside. An overwhelming number of respondents preferred a newsletter for conveying information. Currently, there are numerous newsletters available at most local planning offices with user-friendly guidelines referring to stream management practices. However, these are often provided only to residents who: (1) enter the planning office; and (2) have an interest in learning about managing their streamside property. These results suggest that a more aggressive approach to disseminating such newsletters may be a first step to engaging streamside residents in property management practices that are amenable to their values and beneficial to the stream system.

The general experience of people living along streams suggests considerable interest in improving the overall condition of the stream system. This was revealed my many comments that suggested the decline in salmon populations, stewardship activities, and anecdotes about local environmental history. While improving current conditions was the general sentiment, many respondents also felt as if there were few (if any) places they could look for help. The attitudes towards government revealed a general confusion about what were the rules and regulations pertaining to the steam, as well as where (or to whom) to look for help. Additionally, there was considerable uniformity that the problems occurring to the stream were caused by some 'outside' force, whether government, or neighbors polluting the stream. Regardless, with almost unequivocal interest in improving the stream's condition, there seems to be ample opportunities for engaging an interested public, but the only question is, how?

5. Conclusions and Management Implications

I started this discussion with the question, how can urban ecological information in conjunction with watershed resident preferences aid planners in developing watershed management strategies? This study provides two pieces of evidence to address this question. First, the results suggest recasting the idea of localized 'hot-spots', to context specific linkages between 'hot-spots' and 'cold-spots' or in this case upland areas. For example, by establishing large buffers along all portions of a stream it may be possible to regulate thermal, nutrient, and sediment dynamics in riparian areas, however, without patches of contiguous forest in the upland areas, buffering strategies alone may be insufficient for protection in-stream biology. As such, strategies that emphasize the configuration of upland forests (e.g. distribution, location) in combination with increasing the amount of riparian forests are necessary for addressing the inherent linkages of ecological processes across spatial scales.

A second piece of evidence for managing PSL watersheds entails the process of engaging streamside residents. Linking the issues that streamside residents consider most important with regional goals of improving water quality is consistently highlighted as a condition for sustainable resource management (UNCED, 1992; FAO, 1995). There is considerable interest in improving the condition of PSL streams by those living closes to them. However, given the limited trust of government agencies, alternative options for engaging streamside residents must be considered. One approach could be linking government agencies with non-governmental organization and local universities to meet regional goals. With the number of residents living along streams in urban areas, and the amount of resources required to engage each separately, governments will need to look to other organization for filling needed services. Several examples of such organizations already exist in the PSL; however, there seems to be a need for sufficient financial and legal parameters for fostering further development of outreach mechanisms.

The core messages implied in this research, assessing the linkages between riparian and watershed vegetation patterns, and increasing riparian vegetation amounts through alternative outreach methods, needs to be approached with caution for several reasons. The manner in which these findings manifest in policy also needs to be carefully understood. For example, the findings do not allow us to consider the role that artificial drainage, species of vegetation, or the exact model needed for outreach, still require further development. Issues related to the geographic distribution of the sampling sites, availability of data, and expertise, preclude effective inquiry into these phenomena in this study. Future research will need to address these issues by further elaborating on the subtleties of managing these complex systems.

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